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CALSPAN FIELD SERVICES INC ARNOLD AFS TN AEDC DIV
WIND TUNNEL TESTS OF THE SPACE SHUTTLE FOAM INSULATION WITH SIM--ETC(U)
SEP 81 L A TICATCH, K W NUTT

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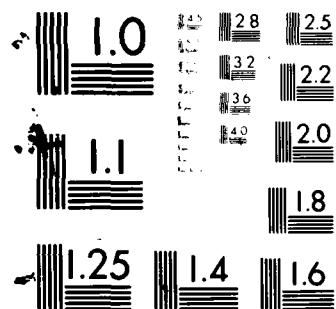
AEDC-TSR-81-V13-ADD

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MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

AEDC-TSR-81-V13 ADDENDUM

LEVEL III (2)

WIND TUNNEL TESTS OF THE SPACE SHUTTLE FOAM INSULATION
WITH SIMULATED DEBONDED REGIONS

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Calspan Field Services, Inc.

September 1981

Final Report for Period August 10, 1981

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APPROVAL STATEMENT

This report has been reviewed and approved.

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Deputy for Operations

Approved for publication:

FOR THE COMMANDER

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NOMENCLATURE

(See AEDC-TSR-81-V13)

1.0 INTRODUCTION

The work reported herein was conducted by the Arnold Engineering Development Center (AEDC), Air Force Systems Command (AFSC), under Program Element 921E02, Control Number 9E02 at the request of the National Aeronautics and Space Administration (NASA), Marshall Space Flight Center (MSFC), Huntsville, Alabama for the Martin-Marietta Corporation (Michoud Operations), New Orleans, Louisiana. The Martin Marietta Corporation project engineer was Mr. Steve Copsey, and the NASA/MSFC project manager was Mr. John Warmbrod. The results were obtained by Calspan Field Services, Inc./AEDC Division, operating contractor for the Aerospace Flight Dynamics testing effort at the AEDC, AFSC, Arnold Air Force Station, Tennessee. The tests were conducted in the von Karman Gas Dynamics Facility (VKF), under AEDC Project No. C342VC. This was the second test entry on this project. The previous tests were reported in AEDC-TSR-81-V13 and this is a continuation (Addendum) to that report.

The conductive coating used for lightning protection on the External Tank of the first space shuttle flight proved to be a potential debris source due primarily to application in relatively thick sections. This test examined three alternate conductive coating materials for debris production potential in convective heating environments simulating flight. The materials used were of much lower viscosity than the previously used material to allow application in thinner coatings. In addition, an experimental deicing compound was applied on several samples to observe any effects the compound might have on the spray-on foam.

A total of 23 samples was tested in the 50-in.-diam Hypersonic Wind Tunnel (C) at the VKF on August 10, 1981. Data were recorded at Mach 10 with tunnel stilling chamber conditions of 1,800 psia and 1,900°R. The nominal wedge angle (WA) varied from 14 to 24 deg to produce local cold wall heating rates ranging from 6 to 10 BTU/ft²-sec.

A summary of the test data transmitted to the sponsor (NASA/MSFC) and the user (MMC) is presented in Table 5.

Inquiries to obtain copies of the test data should be directed to NASA/MSFC/ED33, Marshall Space Flight Center, Huntsville, AL 35812. A microfilm record has been retained in the VKF at AEDC.

2.0 APPARATUS

2.1 TEST FACILITY

(See AEDC-TSR-81-V13)

2.2 TEST ARTICLE

A pretest photograph of a typical specimen is shown in Fig. 9. The specimens were basically flat insulation panels consisting of a 0.13-in. aluminum support plate covered with a 0.6-in. layer of super light ablator (SLA, Mat'l SLA-561) and a 0.75-in. layer of spray-on foam insulator (SOFI, Mat'l CPR-488). Strips of conducting paint of

different thicknesses were placed on the foam. The specimens were attached to the VKF materials wedge for testing as shown in Fig. 10. Installation of the wedge in Tunnel C is illustrated in Fig. 11.

2.3 TEST INSTRUMENTATION

The instrumentation consisted of 9 Gardon gages located on the forward 17.5 inches of the wedge as shown in Fig. 10b.

The Gardon gages used were a special high temperature type, 0.25-in. in diam, with a 0.010-in. thick sensing disk. Each gage had a Chromel-® Alumel® thermocouple to provide the gage edge temperature. These temperatures, together with the gage output, were used to determine the gage surface temperatures and corresponding heat transfer rate, which was then used to calculate the local heat transfer coefficient. These heat transfer coefficients were used to confirm the flow conditions over the sample specimens.

3.0 TEST DESCRIPTION

3.1 TEST CONDITIONS

A summary of the nominal test condition is given below:

<u>M</u>	<u>PT, psia</u>	<u>TT, °R</u>	<u>P, psia</u>
10.10	1800	1900	0.038

A test summary showing the configurations tested and the variables for each is presented in Table 6.

3.2 TEST PROCEDURES

(See AEDC-TSR-81-V13)

3.3 DATA REDUCTION

(See AEDC-TSR-81-V13)

3.4 UNCERTAINTY OF MEASUREMENTS

(See AEDC-TSR-81-V13)

4.0 DATA PACKAGE PRESENTATION

A complete set of all photographic data and tabulated data for this test has been provided to Martin Marietta Corporation. Photographic data which showed significant testing results and a complete set of tabulated data have been provided to NASA/Marshall Space Flight Center/ED33, Huntsville, Alabama. All test specimens for this test have been returned to Martin Marietta Corporation.

A representative posttest photograph is shown in Fig. 12. This is the same test panel shown in the pretest photograph in Fig. 9.

Samples of the tabulated data are presented in Appendix IV. A copy of all data except photographs has been retained on microfilm in the VKF.

REFERENCES

(SEE AEDC-TSR-81-V13)

APPENDIX 1

ILLUSTRATIONS

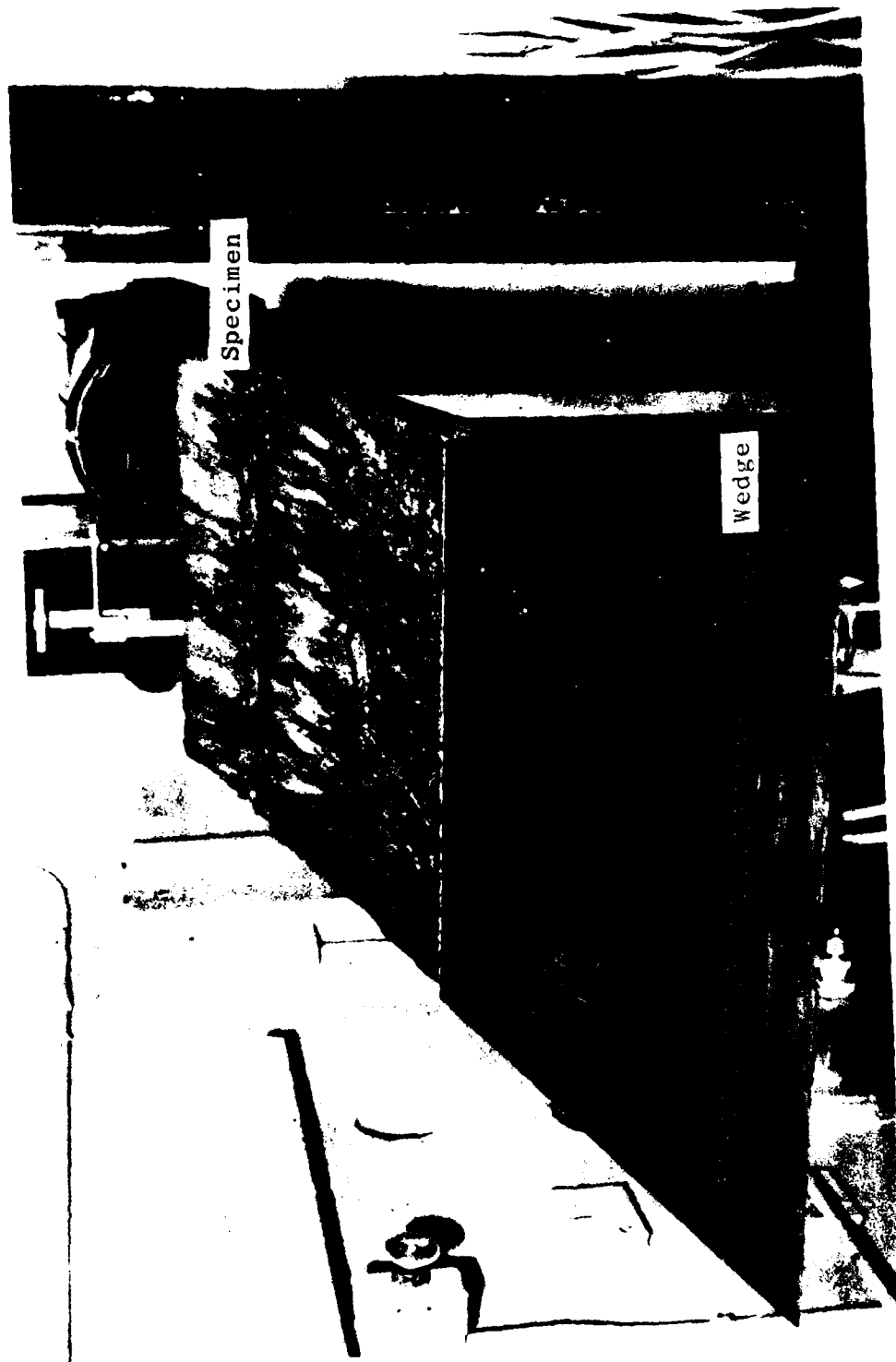
— Strip of Lightning Conduction Paint

— Foam Insulation

VKF TUNNEL C
PRETEST PICTURE
CTC17-1
1 6 INCHES

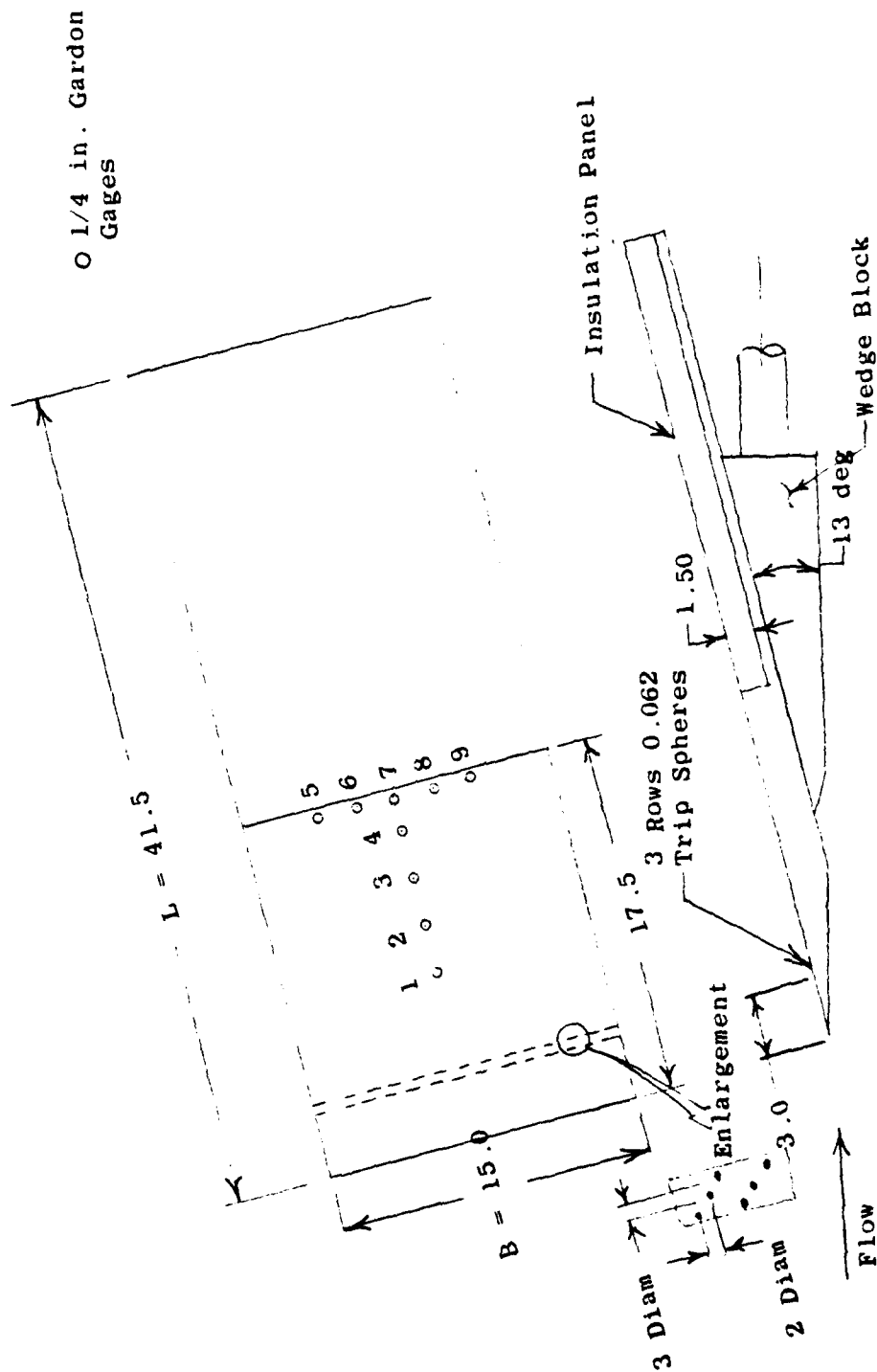
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Figure 9. Typical Specimen Pretest Photograph



a. Photograph of Specimen on Wedge
Figure 10. Installation of Test Specimen on Wedge

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All Dimensions in Inches

b. Sketch of Materials Testing Wedge with Instrumentation

Figure 10. Concluded



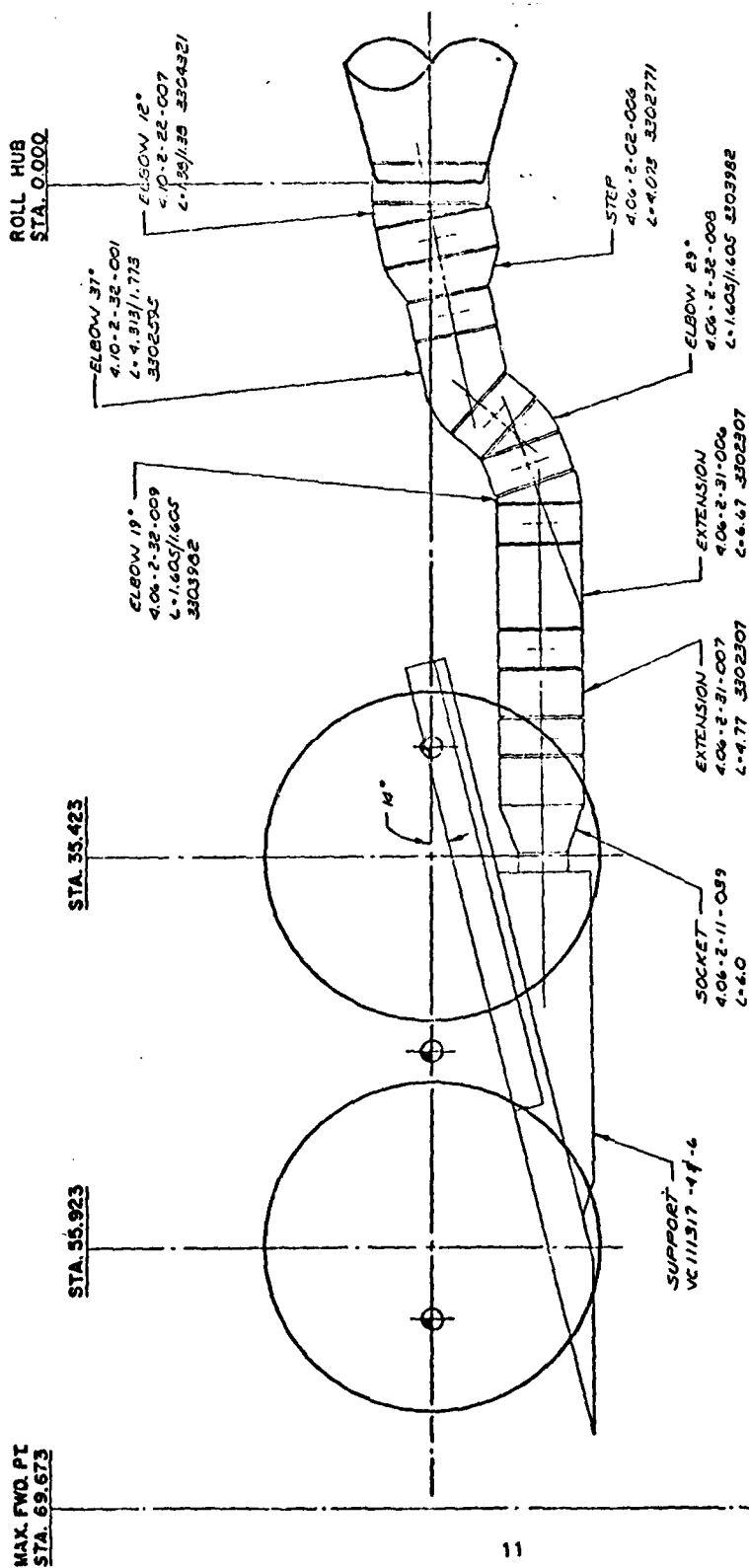
a. Installation Photograph
Figure 11. Installation in Tunnel C

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50-INCH HYPERSONIC TUNNELS B&C

SCALE - 1/3

TUNNEL WALL



NASA/MMC ET DEBOND TEST

VMC - 26

TUNNEL WALL

b. Installation Sketch
Figure 11. Concluded



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Figure 12. Typical Posttest Photograph

APPENDIX II

TABLES

TABLE 5. Data Transmittal Summary

The following items were transmitted to the Sponsor and the User:

	<u>Sponsor</u>	<u>User</u>
	John Warmbrod ED33 Marshall Space Flight Center, AL 35812	Steve Copsey Martin Marietta Dept. 3571 P.O. Box 29304 13800 Gentilly Rd. New Orleans, LA 70189

<u>Item</u>	<u>No. of Copies</u>	<u>No. of Copies</u>
Test Summary Report	1	1
Pre- and Posttest Photographs* (8x10)	1	1
70 mm Stills: contact prints and duplicate negatives (Runs 1-23)	1	1
70 mm shadowgraphs: contact prints and duplicate negatives (Runs 1-23)	1	1
16 mm movies, top view: work prints and optical masters (Runs 1-23)	1	1
16 mm movies, side view: work prints and optical master (Runs 1-23)	1	1
Final Data Package	1	1

* Pretest photos of specimens CTC17-20, 21, 23, 24 were taken by Martin Marietta.

TABLE 6. Test Summary

PT = 1800 psia

TT = 1900°R

RUN NO.	MODEL ID CTC 17-	CONFIGURATION CODE	WEDGE ANGLE	TIME EXPT	APPROX Q-DOT-0
1	1	1	14	73.81	6
2	2	2	19	31.01	8
3	3	3	24	20.73	10
4	4	4	14	42.58	6
5	5	5	19	31.56	8
6	6	6	24	21.56	10
7	7	7	14	45.78	6
8	8	8	19	32.25	8
9	9	9	24	21.77	10
10	10	10	14	3.13	6
11	11	11	19	32.42	8
12	12	12	24	22.00	10
13	16	16	14	44.16	6
14	17	17	19	48.15	8
15	18	18	14	42.64	6
16	19	19	19	33.03	8
17	13	13	14	42.68	6
18	14	14	19	32.12	8
19	15	15	24	22.89	10
20	20	20	14	42.81	6
21	21	21	19	33.10	8
22	23	23	19	62.34	8
23	24	24	24	42.88	10

The approximate QDOT-0 level is based on previous calibration data.

APPENDIX III

REFERENCE HEAT-TRANSFER COEFFICIENT

(SEE AEDC-TSR-81-V13)

APPENDIX IV

SAMPLE TABULATED DATA

DATE COMPUTED 21-AUG-81
TIME COMPUTED 15:12:56
DATE RECORDED 30-AUG-81
TIME RECORDED 2:20:51
PROJECT NUMBER V-C-26

PAGE: 1

NAME	SOURCE	QTIME D.O.	P DFG	CN IN	TJREFLSD SFC	HOUR	MIN	SEC	TIMECL SFC	TIMEEXPT SFC	ITT
I	CTC17-1	-0.04	14.04	25.00	3.747	2	21	26	573	71.80	
M											
	PSIA	DWG H	T R	P PSIA	V PSIA	FT/SEC	LBS/FT ³	END	IMP-SFC	PI-1	RTU/LRM
10.10	1748.93	1900.7	94.6	3.783E+02	2.70	4748.9	1.091E+01		7.53E+00	2.15E+06	4.784E+02

PIC NO.	TIME SEC	TIME/EXP SEC
1	4.27	7.17
2	6.31	4.71
3	8.35	6.75
4	10.45	9.35
5	12.49	10.39
6	14.53	12.43

SHADOWGRAPH TAKEN AT 14.1 SECONDS.

SHADOWGRAPH TAKEN AT 14.1 SECONDS.

7	10.63	14.5
8	12.65	16.55
9	20.11	18.62
10	22.78	20.68
11	25.85	22.75
12	28.92	24.82
13	28.97	26.88
14	31.04	28.93
15	33.10	31.00
16	35.17	33.07
17	37.24	35.13
18	39.31	37.20
19	41.37	39.27
20	43.44	41.33
21	45.50	43.40
22	47.55	45.45
23	49.62	47.52
24	51.68	49.58
25	53.76	51.65
26	55.82	53.72
27	57.87	55.78
28	59.91	57.82
29	62.00	59.90
30	64.07	61.96
31	66.14	64.04
32	68.19	66.08

73.80 MODEL HAS LEFT CENTERLINE.

Sample 2. Photograph History Data

ARMY/CSAF
AFPC DIV
MILK KAWAC GAS PLYAC'S FACILITY
ARMED AIR FORCE STATION, TENNESSEE
NASA/MSC ET TPS DEGRND (PHASE II)

ROW	SOURCE	ALPOL DEC R	CA DEC	IN	CR
1	CICUT-1	-0.07	14.07	25.00	
6	PSIA	DEC R	T	P	PSIA
10.10	1749.23	1900.7	93.6	3.784E-02	2.70
					FT/SEC
				V	PHO
					1.01/FT3
					LMP-SFC/FT2
					NO
					RE
					FT-1
					2.156E+06
					4.784E+02
					ITT
					RTU/LRM